

Sierra Nevada Network Vital Signs Monitoring Plan

Appendix G: Identifying and Prioritizing Vital Signs

Natural Resource Report NPS/SIEN/NRR—2008/072

Linda S. Mutch, Inventory & Monitoring Coordinator
Sierra Nevada Network, Sequoia & Kings Canyon National Parks
47050 Generals Highway
Three Rivers, CA 93271

Meryl Goldin Rose, Ecologist
Sierra Nevada Network Inventory & Monitoring Program
Yosemite Field Station
P.O. Box 700, El Portal, California 95318

Layout and design Barbara BC Gleason/BGleason Design & Illustration, LLC.

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Overview

“Vital sign” is defined in the NPS Inventory & Monitoring Program as “a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values” (<http://science.nature.nps.gov/im/monitor/>).

Identifying and selecting vital signs for the Sierra Nevada Network (SIEN) Inventory and Monitoring Program has required a process of research, multidisciplinary workshops, evaluation, and teamwork. Scientists, managers, administrators, numerous partner agencies, and many others throughout the Sierra Nevada Network have worked together to select and prioritize vital signs (Figure G-1). The current list of 34 candidate vital signs represents a balance of ecosystem driving variables (e.g., weather, climate) and response variables—communities and species (Bennett et al. 2006).

In Chapter 3 of the Vital Signs Monitoring Plan (Mutch et al. 2008) – the main document that this Appendix accompanies—we discuss the process used to select and prioritize candidate vital signs for the Sierra Nevada Network. Please see Chapter 3 for discussion and details. Several of the tables presented in Chapter 3 are duplicated in this Appendix for easier access.

In summary, the Sierra Nevada Network had three individual park-level workshops that involved park staff and scientists from universities and other agencies in identifying candidate lists of vital signs for each network park. Details of these workshops can be found in individual workshop reports (Mutch and Lineback 2001, Mutch 2002, and Mutch and Thompson 2003).

The Science Committee generated a “Network-wide” broad, comprehensive list of 86 vital signs (Table G-1) by refining the three individual park-based lists (i.e., combining similar vital signs, adding vital signs—for

example, components of air and water resources—both of which are already being monitored within parks), reviewing the literature, and developing and refining conceptual models. Vital signs that are already part of established ongoing monitoring programs in SIEN parks, or nationally, were also noted and included where appropriate (e.g., wilderness use, night sky, soundscape).

A Sierra Nevada Network prioritization workshop (March 2005) led to the identification of a refined list of 34 candidate vital signs that represent an integrated approach to an overall monitoring program. Of these, seven vital signs relate directly to air and climate, two relate to geology and soils, seven relate to water, twelve relate to biological integrity, and six relate to ecosystem pattern and processes.

At the close of Phase II of development of our Monitoring Plan (September 2005), we had identified our top 13 vital signs for which it was feasible to proceed with protocol development. The Network has initiated protocol development (or refinement/enhancement where a vital sign is part of an extant monitoring program, e.g., surface water dynamics) (FY2005–2006). Protocol development includes detailed information related to monitoring each vital sign, including importance of monitoring the vital sign, monitoring objectives, sampling design, sampling metric(s), field data collection procedures, data management, staffing, and budget (Oakley et al. 2003).

As protocol development proceeds, the Network will be better able to make an informed decision on how many of the other key vital signs can be incorporated into long-term monitoring. For example, work has been conducted on “a synthetic review of mountain meadow ecosystem monitoring protocols” (Stevenson et al. 2006), and the results of this work are informing decisions on what metric(s) of wetland and meadow ecosystems will allow us to best monitor trends in the condition of these systems. Similar synthesis work has also been conducted on lichens (McCune et al.

2006), airborne contaminants (Western Airborne Contaminants Assessment Project- Landers et al. 2008), and atmospheric (Nitrogen) deposition (Clow et al. 2002, Sickman et al. 2003, Clow 2006, Heard and Sickman in progress).

During the network vital signs prioritization workshop and in the post-workshop vital signs selection process by the Science Committee, special attention was devoted to consideration of the five major stressors of ecological condition in the Sierra Nevada: (1) rapid anthropogenic climate change,

(2) altered fire regimes, (3) non-native invasive species, (4) air pollution, and (5) habitat fragmentation and human use. Candidate network vital signs were evaluated in the context of their relevance to:

- National monitoring goals
- Network monitoring objectives
- Resources management needs
- Relationship to known anthropogenic stressors
- Information value regarding key ecosystems, communities, or processes
- Importance within the conceptual models of the Sierra Nevada

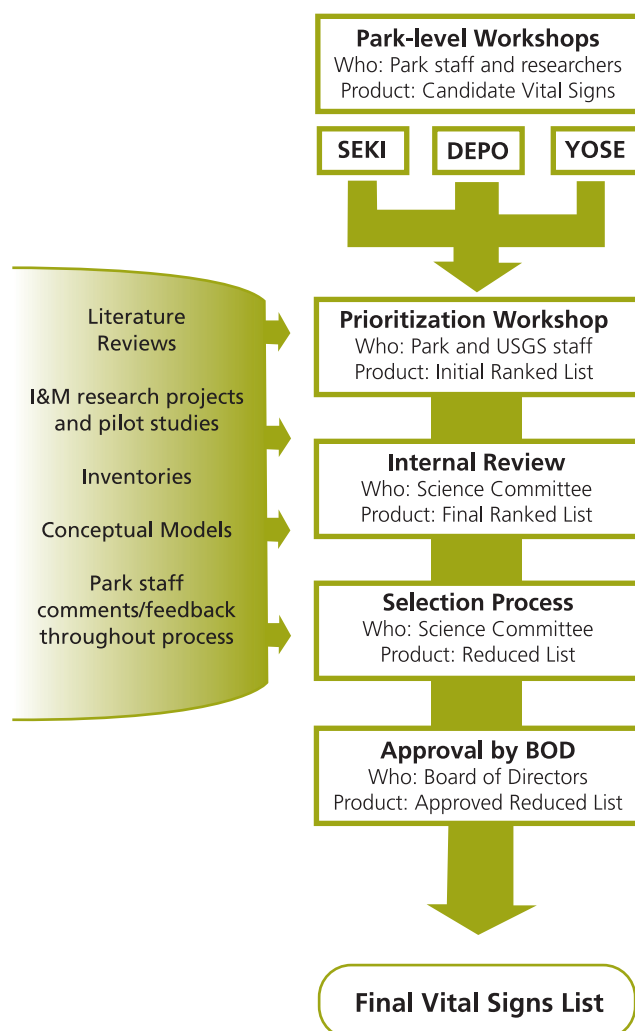


Figure G-1. Vital signs identification, prioritization, and selection process for the Sierra Nevada Network

Table G-1. Sierra Nevada Network List of 86 Vital Signs, in National Framework.

NATIONAL VITAL SIGNS MONITORING FRAMEWORK		
Level 1 Category	Level 2 Category	SIEN Candidate Vital Sign *
Air and Climate	Air Quality	Ozone
		Wet and dry deposition
		Visibility
		Particulate matter
	Weather and Climate	Air contaminants
		Weather-meteorological parameters
Geology and Soils	Geomorphology	Snowpack
		Glacial features and processes
		Hillslope features and processes
		Streambank integrity
		River/stream channel morphology
	Subsurface Geologic Processes	Cave/karst physical processes
		Cave/karst features
	Soil Quality	Soil compaction
		Soil chemistry
		Soil organic matter
Water	Hydrology	Surface water dynamics-streams/rivers/springs/lakes
		Surface water dynamics-wetlands
		Groundwater dynamics
	Water Quality	Water chemistry-surface water
		Water chemistry-groundwater
		Water chemistry-springs
		Toxics
		Fecal bacteria
		Aquatic vegetation-chemistry
		Aquatic macroinvertebrates
		Aquatic microorganisms
		Suspended sediment
Biological Integrity	Invasive Species	Invasive/Alien plants
		Invasive/Alien animals
		Fishes-non-native
	Infestations and Disease	Animal diseases
		Plant diseases
	Focal Species and Communities	Vegetation community composition and structure
		Meadow vegetation communities
		Alpine vegetation communities
		Forest demography
		Yellow pine populations
		Foothill tree populations
		Subalpine/treeline tree populations

Table G-1. Sierra Nevada Network List of 86 Vital Signs, in National Framework, continued

NATIONAL VITAL SIGNS MONITORING FRAMEWORK		
Level 1 Category	Level 2 Category	SIEN Candidate Vital Sign *
Biological Integrity, cont'd	Focal Species and Communities, cont'd	Non-vascular plants
		Phenology of plants and animals
		Invertebrate biodiversity–meadows/wetlands
		Cave invertebrates
		Amphibians
		Reptiles
		Bird populations
		Raptors–non-owl
		Small mammals
		Pika
		Mid-sized carnivores
		Bats
		Mule deer
		Mountain beaver
		Snowshoe hare
		Mountain lions
		Fishes–fish assemblages
		Wildlife communities–Yosemite Valley
	At-risk Biota	Bighorn sheep
		California Spotted Owl
		Great Grey Owl
		Peregrine Falcon
		Mountain yellow-legged frog
		Western pond turtle
		Yosemite toad
		White pine populations
		Giant sequoia populations
		Selected rare plant taxa
		Human/bear interactions
Human Use	Human Effects	Night sky darkness/light intrusion
		Water consumption
	Consumptive use	Firewood consumption
		Visitor use
	Visitor and Recreation Use	Backcountry use
		Stock use and grazing
		Volcanic feature degradation
	Fire	Vegetation community response to fire
		Fuel dynamics
		Fire regimes

Table G-1. Sierra Nevada Network List of 86 Vital Signs, in National Framework, continued

NATIONAL VITAL SIGNS MONITORING FRAMEWORK		
Level 1 Category	Level 2 Category	SIEN Candidate Vital Sign *
Human Use, cont'd	Land Cover and Use	Landscape mosaics
		Areal extent of meadows
		Land use
	Soundscape	Soundscape
	Nutrient Dynamics	Biogeochemical cycling
	Productivity	Net primary productivity
		Carbon storage

* derived from park-level vital signs workshops

Table G-2. Criteria applied to each of the 86 candidate vital signs, including weighting applied to each criteria category for ranking purposes.

Category (weight)	Criteria if <i>strongly agree</i> (score=1), otherwise (score=0)
Ecological Relevance, Geographical Scope, Data Response & Sensitivity (60%)	<ul style="list-style-type: none"> There is a strong, defensible linkage between the vital sign and the ecological function or critical resource it is intended to represent.
	<ul style="list-style-type: none"> The vital sign represents a resource or function of high ecological importance based on the conceptual models of the system and the supporting ecological literature. For example: <ul style="list-style-type: none"> Vital sign represents a species, community, process and/or place of high ecological importance. Vital sign is connected to multiple components or processes in the system. Vital sign has broad ecological scope—such as biodiversity, net primary productivity, biogeochemical cycling.
	<ul style="list-style-type: none"> The vital sign has broad geographic scope—it occurs in at least two out of three network units (Devils Postpile, Sequoia & Kings Canyon, and Yosemite) and has broad spatial extent within the parks or across the region.
	<ul style="list-style-type: none"> The vital sign is anticipatory. It can signify an impending change in the ecological system or in important resources.
	<ul style="list-style-type: none"> The vital sign is sufficiently sensitive to small changes in linked or related resources or functions.
	<ul style="list-style-type: none"> Baseline data exist within the region, and/or threshold values are specified in the literature that can be used to measure deviance from a desired condition.
	<ul style="list-style-type: none"> There is an obvious, direct application of the data to key current or future management decisions.
	<ul style="list-style-type: none"> Monitoring results are likely to provide early warning of resource impairment, and will thereby save park resources and money.
	<ul style="list-style-type: none"> Data are of high interest to the public.
Management Relevance & Utility (40%)	<ul style="list-style-type: none"> There is a direct application of the data to performance (GPRA) goals and long-term planning.
	<ul style="list-style-type: none"> The vital sign is an extremely vulnerable or at-risk resource or process.

Network-wide Prioritization Workshop

At a two-day network-level vital signs prioritization workshop in April 2005, 40 participants from SIEN parks, divided into four subject-area work groups (physical resources, wildlife, vegetation, and ecosystem pattern&process/human use), ranked subsets of vital signs generated from the comprehensive list (Table G-1).

Detailed supporting information (justification) for each vital sign was provided, including a full description of the vital sign in context of the Network, stressors, management issues, potential monitoring questions, and others. A list of interdisciplinary criteria (Table J-2) and lively debate by team members was used to rank each vital sign. Because all vital signs ranked had some importance in the Network, a “strongly agree” (versus just “agree/yes”) was necessary in order for a vital sign to receive a score of 1—otherwise the vital sign received a score of 0.

A database created by the Mojave Network (Kris Heister, Coordinator, and Craig Palmer, Data Manager) was modified by SIEN Data Specialist Rose Cook to be used at the SIEN workshop. A transcriber with computer recorded the vital sign’s score directly into the database for each of the of the 4 work groups. The 86 vital signs were ranked by the four workgroups (wildlife=26 vital signs, vegetation=14, physical=28, landscape/human use=18).

A few additional ranking criteria (described below) were applied to each vital sign during the prioritization workshop. These were re-evaluated on their merit by the science committee post-workshop. After re-evaluation, the vital signs were mathematically re-ranked.

Re-evaluation factors included evaluation for redundancy, relevance, and “goodness of fit” (i.e., how well could the criterion be applied to the vital sign). Some criterion were easy to apply when the vital sign was a plant community or animal, but less applicable for stressor physical processes vital signs.

Where necessary, the work groups

rescored a vital sign based on the new-or-reworded criterion. Original rankings for all vital signs have been maintained for future use, where-and-when appropriate.

Criteria that were modified or deleted are discussed individually as follows, along with reasoning therefore, with vital signs rescored where necessary

- “The vital sign has a high signal to noise ratio and does not exhibit large, naturally occurring variability.” Vital signs were scored using this criterion, but the results were not included in the initial round of ranking—this criterion will have more applicability when specific measures for vital signs are determined (signal-to-noise will vary depending upon the metric).
- “The vital sign has broad geographic scope—it is relevant across the network parks and/or has regional significance.” Some misunderstanding of the intent of this criterion occurred so it was revised and reapplied as follows: The vital sign has broad geographic scope—it occurs in at least 2 out of 3 network units (DEPO, SEKI, YOSE) and it has broad spatial extent in the parks or across the region. As re-described, a rare species evenly distributed across the parks would score a zero.
- “Reference conditions exist within the region, and/or threshold values are specified in the literature that can be used to measure deviance from a desired condition. Reworded to: “Baseline data” exist within the region....

Two criteria were decided to be very similar, and so they were combined as a single criterion, as follows: There is an obvious, direct application of the data to key current or future management decisions. If either criterion had received a “strongly agree”, then “strongly agree” was applied in the ranking using the single criterion. The two original criteria that were combined are as follows: (1) “[t]here is an obvious, direct application of the data to a key management decision, or for evaluating the effectiveness of past management decisions”, and (2) “[d]ata provide information needed for future management decisions.”

The following criterion was deemed too similar to another and was removed from the scoring procedure: “[t]he vital sign will produce results that are interpretable for park managers, policy makers, research scientists, and the general public, all of whom should be able to recognize the implications of the vital sign’s results for protecting and managing the parks’ natural resources.” Other criteria already applied concerns of the public and management decisions. We applied this criterion to reflect the concept of “interpretability.”

The following criterion was rewritten and applied more rigorously: “The vital sign is a vulnerable or at-risk resource or process and data on its status are needed to mitigate undesirable changes in species or communities (i.e., rapid declines of native species or increases in invasive species), or alterations of critical processes or ecosystem functions.” The new criterion was rewritten and applied as follows: [t]he vital sign is a vulnerable or at-risk resource or process (a “strongly agree” was only applied if there was a sense of urgency, i.e., the resource or process is in obvious decline. An ‘N/A’ was applied to all non-native species vital signs.

Finally, “Legal Mandate” will be addressed with Science Committee or work groups as there are specific state and federal legislation, designations, and authorizations that define legal mandate, particularly where individual species are concerned.

Post Workshop Selection of Network Vital Signs

Using the ranked results of the prioritization workshop (Table G-3), and comments and recommendations from workshop participants, the Science Committee examined the scores and, where necessary, reevaluated each vital sign based on scientific merit and context. For example, some vital sign—for which there was an overall lack of information and therefore inability to apply some criteria—received a low score (e.g., lichens, phenology) during the workshop, but nevertheless could be good indicators of ecosystem condition.

Finalization of the candidate vital signs list occurred through several subsequent meetings of the Science Committee—vital signs were categorized as follows

- Vital signs we consider to be good indicators of the larger ecosystem or resource condition (included in Table G-4).
- Vital signs that—although we do not consider them to be good indicators of the larger ecosystem (at least with information currently available)—are being considered as a candidate vital sign because they are themselves a resource we believe is important to monitor. Night sky, soundscape, visibility, cave biota and cave/karst physical processes are the five of these included in Table G-4.
- De-listed Vital Signs—those identified as weak “vital signs” or vital signs whose condition could be improved by straightforward management actions (e.g., stock use, visitor use, firewood consumption).

Table G-3. Initial results of ranking of SIEN vital signs (weighted 60:40—ecological: management significance, respectively)

VITAL SIGN	SCORE	RANK	VITAL SIGN	SCORE	RANK
Fire Regimes	1.000	1	Fishes—Non-native	0.620	39
Bird Populations	0.920	2	Visitor Use	0.620	39
Vegetation Community Response to Fire	0.920	2	Land use	0.600	44
Air Contaminants	0.900	4	Streambank Integrity	0.560	45
Toxics	0.900	4	Suspended Sediments	0.560	45
Weather—Meteorological Parameters	0.900	4	Areal Extent of Meadows	0.560	45
Surface Water Dynamics	0.840	7	Foothill Tree Populations	0.560	45
Fuel Dynamics	0.840	7	California Spotted Owl	0.560	49
Subalpine/Treeline Tree Populations	0.840	7	Yosemite Toad	0.540	49
White Pine Populations	0.840	7	Invasive / Alien Animals	0.540	49
Snowpack	0.820	11	Cave / Karst Features	0.520	52
Mountain Yellow-legged Frog	0.820	11	Fecal Bacteria	0.500	53
Meadow Vegetation Communities	0.820	11	Soil Compaction	0.500	53
Ozone	0.800	14	Net Primary Productivity	0.500	53
Particulate Matter	0.800	14	Phenology (Plants, Animals)	0.500	53
Stock Use and Grazing	0.800	14	Alpine Vegetation Communities	0.500	53
Invasive / Non-native Plants	0.800	14	Aquatic Microorganisms	0.480	58
Water Chemistry—Surface water	0.760	18	Glacial Features and Processes	0.480	58
Amphibians	0.760	18	Aquatic Macroinvertebrates	0.480	58
Biogeochemical Cycling	0.760	18	River / Stream Channel Morphology	0.480	58
Water Consumption	0.760	18	Hillslope Features and Processes	0.480	58
Forest Demography	0.760	18	Mountain Beaver	0.480	58
Wet and Dry Deposition	0.740	23	Mule Deer	0.480	58
Bats	0.740	23	Nonvascular Plants	0.480	58
Macro-invertebrates—Wetlands	0.740	23	Cave Invertebrates	0.460	66
Landscape Mosaics	0.740	23	Mountain Lion	0.460	66
Mid-sized Carnivores	0.720	28	Raptors - Non-owls	0.460	66
Backcountry Use	0.720	28	Selected Rare Plant Taxa	0.440	69
Giant Sequoia Populations	0.720	28	Soil Chemistry	0.400	70
Bighorn Sheep	0.700	31	Small Mammals	0.400	70
Fishes—Fish Assemblages	0.700	31	Reptiles	0.380	72
Water Dynamics - Wetlands	0.680	33	Pika	0.380	72
Groundwater Dynamics	0.660	34	Cave / Karst Physical Processes	0.360	74
Vegetation Community Comp. and Structure	0.660	34	Animal Disease	0.360	74
Yellow Pine Populations	0.660	34	Firewood Consumption	0.360	74
Plant Disease and Insects—non-native	0.650	37	Western Pond Turtle	0.340	77
Visibility	0.640	38	Soil Organic Matter	0.300	78
Peregrine Falcon	0.620	39	Aquatic Vegetation - Chemistry	0.300	78
Great Grey Owl	0.620	39	Night sky Darkness - Light Intrusion	0.280	89
Human-bear Interactions	0.620	39	Soundscape	0.253	81

Table G-3. Initial results of ranking of SIEN vital signs, cont'd

VITAL SIGN	SCORE	RANK
Plant Diseases and Insects-Native	0.200	82
Water Chemistry - Groundwater	0.100	83
Carbon Storage	0.100	83
Volcanic Feature Degradation	0.100	83
Water Chemistry - Springs	0.080	86
Snowshoe Hare	0.080	86

Board of Directors Review

Following Science Committee selection of recommended vital signs, the Coordinator provided the Board of Directors, or BOD, (who oversee the coordinator and provide guidance to the Network) the following for review:

- description of the selection process
- list of the proposed final vital signs, as selected by the Science Committee
- short description of each vital sign, including its meaning and significance

At a one-day meeting on 29 August 2005, the BOD approved the Science Committee recommendations as the Network's final vital signs. At this meeting, the Coordinator reviewed the three items noted above, including soliciting input and direction. The BOD provided helpful critiques and discussion and expressed much satisfaction with the collaborative process that SIEN undertook to create and refine the list.

Regarding the final vital signs list, the Network Coordinator requested that the BOD recognize that:

1. Minor changes to vital signs could be expected in the future.
2. As sampling protocol development commences during Phase III, some major changes may be requested for BOD approval, including addition or deletion of vital signs.
3. A strong possibility exists that the current list is outside the funding available through the Natural Resource Challenge.

At a December 5, 2006 Board of Directors meeting, the Board members indicated that their priorities for vital signs (and monitoring protocol development) and implementation are as follows:

1. highest priority—landscape dynamics, meadow ecological integrity (meadow/wetland water dynamics, meadow/wetland plant communities, macro-invertebrates—meadows/wetlands), and forest stand population dynamics;
2. high priority—lakes (water chemistry, surface water dynamics, amphibians), streams & rivers (water chemistry and surface water dynamics), weather & climate; and
3. lower priority—birds, and non-native invasive plants.

Based on these priorities, the SIEN staff and Science Committee will evaluate the timeline, available resources and expertise, and the proposed budget (Vital Signs Monitoring Plan, chapter 10, Mutch et al. 2008), and communicate to the Board revised budget and schedule alternatives associated with this prioritization, including the consequences for the timing of protocol implementation.

Table G-4. Reduced list of vital signs generated by Network-wide prioritization (workshop and science committee) and relevance to each park unit. Vital signs selected for protocol development in the next two years are bolded. See key below the table for symbol explanation.

LEVEL 1	LEVEL 2	VITAL SIGN	DEPO	KICA	SEQU	YOSE
Air and Climate	Air Quality	Ozone	✧	✧	●	●
		Airborne contaminants	✧	✧	✧	✧
		Atmospheric deposition	✧	✧	●	●
		Particulate matter	✧	✧	●	●
		Visibility	✧	✧	●	●
	Weather and Climate	Weather and climate	+	●	●	●
		Snowpack	+	●	●	●
Geology and Soils	Geomorphology	Stream channel morphology	✧	✧	✧	●
	Subsurface Geologic Processes	Caves/karst physical processes	-	●	✧	✧
Water	Hydrology	Surface water dynamics	●	+	+	+
		Wetland water dynamics	+	+	+	+
	Water Quality	Water chemistry	+	+	+	+
		Toxics	✧	✧	✧	✧
		Snow chemistry	✧	✧	✧	✧
		Macro-invertebrates	✧	✧	✧	✧
		Microorganisms	✧	✧	✧	✧
Biological Integrity	Invasive Species	Non-native invasive plants	-	+	+	+
	Focal Species or Communities	Selected plant communities	✧	✧	✧	✧
		Forest dynamics	+	+	+	+
		Phenology	✧	✧	✧	✧
		Wetland plant communities	+	+	+	+
		Amphibians	-	+	+	+
		Birds	+	●	✧	●
		Macro-invertebrates (wetlands)	+	+	+	+
		Cave biota	✧	✧	✧	✧
		Bats	✧	✧	✧	✧
		Meso-carnivores	✧	✧	✧	✧
Landscapes (Ecosystem Pattern and Processes)	Fire and Fuel Dynamics	Fire regimes	●	+	+	+
		Fire effects on plant communities	●	●	●	●
	Landscape Dynamics	Landscape Dynamics	+	+	+	+
	Viewscape	Night sky	✧	✧	✧	✧
	Soundscape	Soundscape	✧	✧	✧	✧
	Nutrient Dynamics	Biogeochemical cycling	✧	✧	✧	✧
	Energy Flow	Net primary productivity	✧	✧	✧	✧

Legend:

- ✦ Vital signs that the Network will use to develop protocols and implement monitoring, using funding from the vital signs or water quality monitoring programs.
- Vital signs that are monitored by a network park, another NPS program, or by another federal or state agency using other funding. The Network will collaborate with these other monitoring efforts.
- ✧ High-priority vital signs for which monitoring will likely be done in the future, but which cannot currently be implemented because of limited staff and funding.
- Vital sign does not apply to park, or for which there are no foreseeable plans to conduct monitoring.

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